AIR QUALITY AND AIR QUALITY RELATED VALUES MONITORING CONSIDERATIONS FOR THE SOUTHERN PLAINS NETWORK

December 2005

Introduction

The Southern Plains Network (SOPN) of the National Park Service (NPS) Inventory and Monitoring Program includes Alibates Flint Quarries National Monument (NM), Bent's Old Fort National Historic Site (NHS), Capulin Volcano NM, Chickasaw National Recreation Area (NRA), Fort Larned NHS, Fort Union NM, Lake Meredith NRA, Lyndon B. Johnson NHP, Pecos NHP, Sand Creek Massacre NHS, and Washita Battlefield NHS. All of the network units are Class II air quality areas. Air quality and related information for the network is at http://www2.nature.nps.gov/air/Permits/ARIS/networks/index.htm.

Although most of the park units in the network are some distance from cities and pollution sources, many experience occasional poor air quality from pollutants such as ozone, nitrogen oxides, sulfur dioxide, volatile organic compounds, particulate matter, and toxics. These air pollutants affect, or have the potential to affect, air quality and natural resources in SOPN, including vegetation, wildlife, soils, water quality, and visibility. High levels of ozone in the area, for example, may affect vegetation, as well as the health of park visitors and staff. Nitrogen compounds from the atmosphere have the potential to affect water quality and biota, soil nutrient cycling and plant species composition. Pollutant particles in the air reduce visibility in the region and affect how far and how well we can see. Atmospheric deposition of toxic organic compounds and metals, including mercury, may have a wide range of effects on fish and wildlife. The following sections describe air pollutant emissions, air quality monitoring, and air pollutant concerns for resources in the network.

Air Pollutant Emissions

Air quality in the network is affected primarily by air pollution sources in Texas, Oklahoma, New Mexico, Colorado, and Kansas, although more distant sources can also affect the area's air quality. Air pollutant emissions come from a variety of sources, including mobile sources (e.g., cars, trucks, off-road vehicles), stationary sources (e.g., power plants and industry), and area sources (e.g., agriculture, fires, and road dust).

Some of the most common and abundant pollutant emissions include nitrogen oxides, ammonia, and sulfur dioxide. Figure 1 shows distribution maps for emissions of nitrogen oxides, ammonia, and sulfur dioxide in Texas, Oklahoma, New Mexico, Colorado, and Kansas. Major sources of nitrogen oxides include cars and other mobile sources, compressors, power plants and industry. Agricultural activities are the main sources of ammonia. The major sources of sulfur dioxide are coal-burning power plants, industry, and diesel engines. Additional information on pollutant sources can be found at http://www.epa.gov/air/data/index.html.

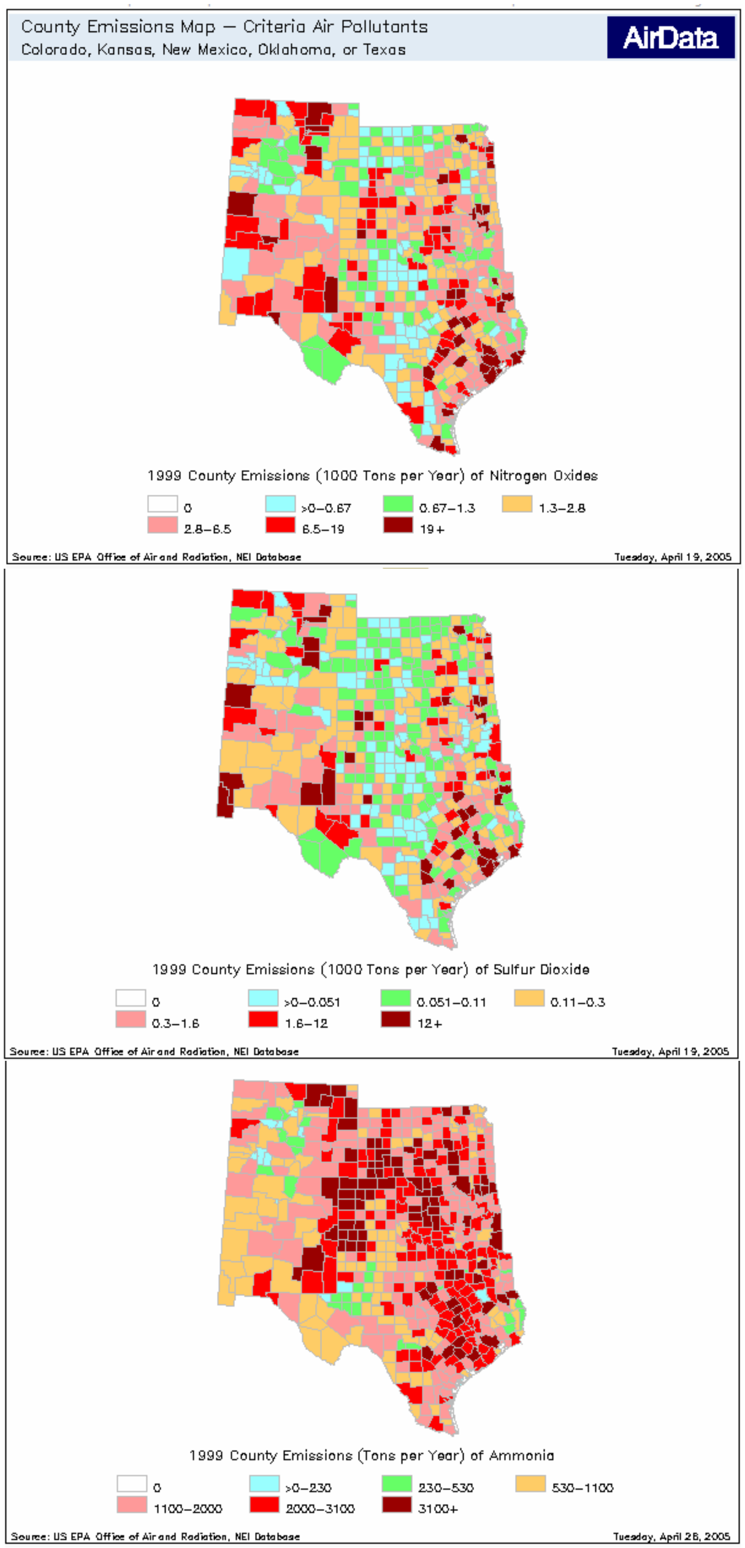

Figure 1. Air pollutant emissions of nitrogen oxides, ammonia, and sulfur dioxide, by county, in Texas, Oklahoma, New Mexico, Colorado, and Kansas. Emissions are given in thousands of tons per year for nitrogen oxides and sulfur dioxide and tons per year for ammonia (from EPA AirData at http://www.epa.gov/air/data/index.html).

Air Quality Monitoring and Effects

Figure 2 shows current air quality monitoring near SOPN park units. Table 1 lists air quality monitoring site locations. There are no air quality monitors in the units, but nearby monitors may be representative of conditions in the network units. Types of monitoring include ozone monitoring by States (Ozone); wet deposition (rain, snow) monitoring of atmospheric pollutants by the National Atmospheric Deposition Program/National Trends Network (NADP/NTN); wet deposition monitoring of mercury by the Mercury Deposition Network (MDN); dry deposition (dryfall) monitoring of atmospheric pollutants by the Clean Air Status and Trends Network (CASTNet); and visibility monitoring by the Interagency Monitoring of Protected Visual Environments (IMPROVE) Program.

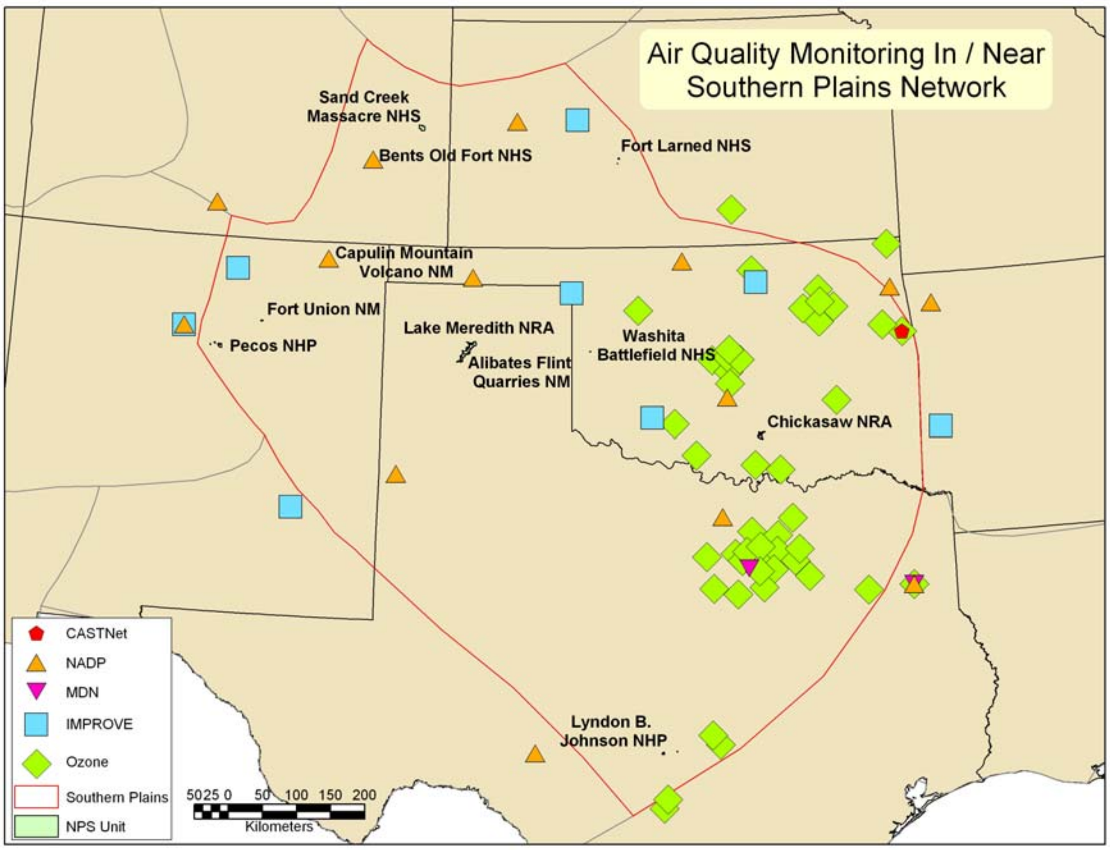

Figure 2. Air quality monitoring in SOPN (CASTNet= Clean Air Status and Trends Network; NADP= National Atmospheric Deposition Program; MDN=Mercury Deposition Network; IMPROVE=Interagency Monitoring of Protected Visual Environments; Ozone=ozone monitoring by States.

Table 1. Current air quality monitoring sites near NPS units in SOPN. Air quality data is available from the monitoring network websites listed below. Data from distant monitors are unlikely to be representative of conditions in a park unit; Air Atlas estimates should be used in these cases. Air quality estimates for SOPN park units are available from NPS Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm.

MONITORING NETWORK	SITE I.D.	LOCATION
CASTNet	CHE185 (Cherokee Nation)	Adair County, OK
NADP	CO00 (Alamosa) CO01 (Las Animas Fish Hatchery) KS32 (Lake Scott State Park) NM07 (Bandelier National Monument) OK29 (Goodwell Research Station) OK00 (Salt Plains National Wildlife Refuge) OK17 (Great Plains Apiaries) TX02 (Muleshoe National Wildlife Refuge) TX56 (LBJ National Grasslands) TX21 (Longview) TX16 (Sonora) AR27 (Fayetteville)	Alamosa, CO Bent County, CO Scott County, KS Los Alamos County, NM Texas County, OK Alfalfa County, OK McClain County, OK Bailey County, TX Wise County, TX Gregg County, TX Edwards County, TX Washington County, AR
MDN	TX50 (Fort Worth) TX21 (Longview) OK15 (Newkirk)	Tarrant County, TX Gregg County, TX Kay County, OK
IMPROVE	CEBL1 (Cedar Bluff) CHER1 (Cherokee Nation) ELLI1 (Ellis) WIMO1 (Wichita Mountains NWR) SACR1 (Salt Creek NWR) BAND1 (Bandelier National Monument) WHPE1 (Wheeler Peak) ELDO1 (El Dorado Springs)	Trego County, KS Kay County, OK Ellis County, OK Comanche County, OK Grant County, NM Los Alamos County, NM Taos County, NM Cedar County, MO
Ozone		There are a number of ozone monitors located near Oklahoma City (OK), Tulsa (OK), Dallas/Ft. Worth (TX), Austin (TX), and San Antonio (TX)

NADP/NTN = National Atmospheric Deposition Program at http://nadp.sws.uiuc.edu/
MDN = Mercury Deposition Network at http://nadp.sws.uiuc.edu/mdn/
CASTNet = Clean Air Status and Trends Network at http://www.epa.gov/castnet/
IMPROVE = Interagency Monitoring of Protected Visual Environments at http://vista.cira.colostate.edu/views/
Ozone = EPA AirData at http://www.epa.gov/air/data/index.html or NPS AirWeb at http://www2.nature.nps.gov/air/data/index.htm

Air Quality Estimates: Air Atlas

NPS Air Resources Division has developed Air Atlas to provide estimates of air quality conditions for park units without on-site monitoring (http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm). Air Atlas serves as the air inventory for parks and is a mini-GIS tool that provides national maps and an associated look-up table with baseline values of air quality parameters for all Inventory and Monitoring (I&M) parks in the U.S. The values are based on averaged 1995-1999 data. An update with 1999-2003 data will be available in summer 2005.

The estimated air quality values provided in Air Atlas are based on the center of the polygon defining the park or multiple units of the park. Data from all available monitors operated by NPS, States, EPA, and other programs are used for the interpolation of the air quality values.

Air Atlas contains a comprehensive set of air quality parameters. Table 2 summarizes selected air quality parameters for SOPN.

Table 2. Estimates of selected air quality parameters for units of SOPN, 1995-1999 (from Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm).

SOUTHERN PLAINS NETWORK		Ozone --					NADP (kg/ha/yr) ===:		Visibility - IMPROVE	
PARK	CLASS	2ndHi1hr	4thHi8hr	#8hr>85	#1hr>100	Sum06_3Mo	Total S	Total N	b_{ext}Clear	b_{ext}Hazy
Alibates Flint Quarries NM	2	104.4	77.9	3.5	7.1	21.9	1.44	2.51	8	34
Bent's Old Fort NHS	2	98.4	71.8	1.7	2.2	8.7	1.32	2.69	7	26
Capulin Volcano NM	2	92.6	68.8	0.7	0.9	10.7	1.18	2.14	7	26
Chickasaw NRA	2	122.4	90.0	9.3	23.0	24.2	2.56	3.05	18	97
Fort Larned NHS	2	106.6	78.9	3.4	5.3	21.2	2.12	3.75	9	44
Fort Union NM	2	88.6	68.0	0.2	0.3	16.3	1.14	1.81	8	27
Lake Meredith NRA	2	102.6	76.7	3.0	5.7	21.9	1.44	2.5	8	34
Lyndon B. Johnson NHP	2	126.8	89.2	8.9	24.9	17.4	2.02	2.12	13	60
Pecos NHP	2	89.4	68.2	0.2	0.2	15.8	1.13	1.71	8	27
Sand Creek Massacre NHS	2	NA	71.9	NA	2.3	8.7	1.49	3.04	7	27
Washita Battlefield NHS	2	NA	86.7	NA	16.0	21.8	1.83	2.96	10	44

Class: refers to an area's designation under the Clean Air Act
Ozone information represents 5-yr average of annual values from 1995-1999
2nd High 1 hr concentration (ppb): indicates peak values for ozone; old standard of 0.12 ppm (120 ppb) was based on 2nd hi,1-hr average
4th high 8 hr concentration (ppb): new ozone standard of 0.08 ppm (80 ppb) is based on 4th hi, 8-hr average
#8 hours>85 ppb: indicates how often the area would be in violation of the new 8-hr standard of 0.08 ppb
hours> 100 ppb: high peaks in ozone concentration, as well as cumulative dose, contribute to vegetation injury
SUM06_3mon (ppm-hrs) - sum of hourly ozone conc.≥0.06 ppm (60 ppb) over 3 months (~ growing season), i.e., cumulative ozone dose
NADP information represents 6-yr average of annual values from 1995-2000
NADP deposition (kg/ha/yr): estimate of pollutants deposited to ecosystem by precipitation (NADP-National Atmospheric Deposition Program)
NADP Total S - sulfur from sulfate deposited by precipitation
NADP Total N - inorganic nitrogen (ammonium plus nitrate) deposited by precipitation
Visibility IMPROVE information represents 5-yr average of annual values from 1995-1999
bextClear - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average clear day
bextHazy - measure of light scattering and absorption, i.e., extinction, by particles in the air on an average hazy day
NA: not available

Wet Deposition Monitoring of Atmospheric Pollutants

Estimates of wet deposition for park units are available from Air Atlas. Figure 2 shows locations of NADP/NTN wet deposition samplers near SOPN units. Table 1 lists the site identification codes and locations. NADP/NTN collects data on both pollutant deposition (in kilograms per hectare per year – kg per ha per yr) and pollutant concentration (in microequivalents per liter – μeq per L). Deposition measurements are useful because they give an indication of the total annual pollutant loading at the site. However, deposition varies with the amount of annual precipitation. Concentration measurements are independent of precipitation amount;

therefore, concentration provides a better indication of whether ambient pollutant levels are increasing or decreasing over time, despite rainfall fluctuations. In general, wet deposition and concentration of sulfate, nitrate, and ammonium are low in the western U.S. relative to the Midwest and East. Pollutant deposition in the SOPN is consistent with this pattern. A trend analysis of 1994-2003 data indicates that sulfate concentrations are decreasing at many sites in the West; however, nitrate and ammonium concentrations are increasing at many sites (Appendix A, figures A.1-A.3).

Dry Deposition Monitoring of Atmospheric Pollutants
Estimates of dry deposition for park units are available from Air Atlas. There is only one dry deposition CASTNet sampler near the SOPN (figure 2, table 1), and it is located close to the eastern border of Oklahoma and may not be representative of SOPN units.

Total Atmospheric Deposition
When assessing ecosystem impacts from atmospheric deposition it is desirable to have estimates of total deposition, that is, wet plus dry deposition plus cloud/fog deposition. Cloud and fog deposition are not likely to be significant in the SOPN; total deposition can be estimated from wet plus dry deposition. However, the dry deposition data record at CHE185 is incomplete. In the lack of dry deposition data, total deposition can be estimated by assuming that dry deposition rates are approximately equal to wet deposition rates and therefore,

Total deposition = 2 (wet deposition)

NADP/NTN estimates of wet inorganic nitrogen deposition (nitrate plus ammonium) for 2003 (http://nadp.sws.uiuc.edu/lib/data/2003as.pdf) range from approximately 1.5-3.5 kg per ha per year in the SOPN area, so that:

Total inorganic N deposition = 3-7 kg per ha per year

NADP/NTN estimates of wet sulfur deposition for 2003 range from approximately 0.3-0.5 kg per ha per year in the SOPN area, so that:

Total S deposition = 0.6-1 kg per ha per year

These estimates suggest that deposition of both nitrogen and sulfur are elevated above natural levels of deposition. Estimates of natural deposition for either sulfur or nitrogen in the West are approximately 0.2 kg per ha per yr.

Atmospheric Deposition Effects to Ecosystems
Atmospheric deposition of nitrogen and sulfur compounds can affect water quality, soils, and vegetation. Both nitrogen and sulfur emissions can form acidic compounds (e.g., nitric or sulfuric acid); when deposited into ecosystems with low buffering capacity, acidification of waters or soils can occur. Park units in the SOPN are unlikely to be sensitive to acidification because of high amounts of buffering cations, such as calcium and magnesium, in their soils and waters.

Deposition of nitrogen compounds can also have a fertilization effect on waters and soils. In some areas of the country, elevated nitrogen deposition has been shown to alter soil nutrient cycling and vegetation species composition. Arid ecosystems, typical of SOPN ecosystems, are often nitrogen-limited. Over time, excess nitrogen deposition may cause native plants that have adapted to nitrogen-poor conditions to be out-competed and replaced by nitrogen-loving nonnative grasses and other exotic species. In addition to changes in species composition, there may be increases in productivity, resulting in increased biomass (i.e., fuel loading) and fire frequency.

Ground-level Ozone Monitoring

Estimates of ozone peak concentrations and exposure metrics for SOPN park units can be obtained from AirAtlas. There are no ozone monitors in any of the units; however, State and local air quality agencies operate a number of ozone monitors near SOPN park units (figure 2). Most of these monitors are placed to characterize ozone concentrations in urban areas, including Tulsa, Oklahoma City, Dallas/Ft. Worth, Austin, and San Antonio.

Data from these monitors has been used by the States and EPA to determine compliance with the EPA ozone health standard (based on an 8-hr averaging period). Part or all of 474 counties nationwide are designated as nonattainment for either failing to meet the 8-hour ozone standard or for causing a downwind county to fail (Figure 4). Nonattainment areas include the Dallas/Ft. Worth metropolitan area and San Antonio. States are required to develop plans to bring these areas into compliance with the standard. A trends analysis for 1994-2003 indicates that ozone is increasing in many areas of the West (Appendix A, figure A.4).

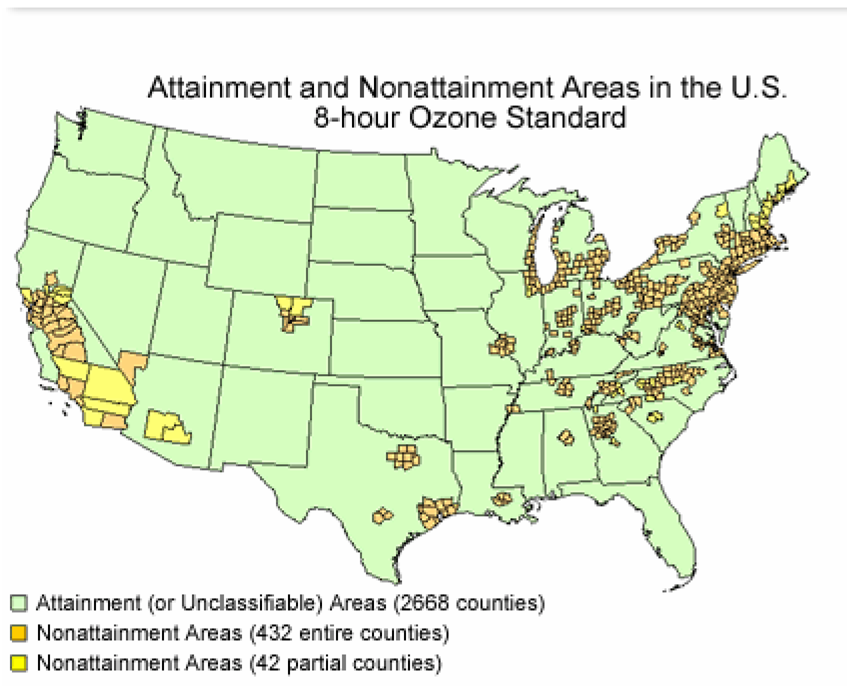

Figure 5. Attainment and nonattainment areas in the U.S. for the 8-hr ozone standard (from http://www.epa.gov/oar/oaqps/glo/designations/index.htm).

Ground-level ozone is produced by the reaction of nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. Ozone is a strong oxidant. Upper-atmospheric ozone (i.e., stratospheric ozone) acts as a protective shield against ultraviolet radiation; ground-level ozone (i.e., tropospheric ozone) is harmful to human health and vegetation. Although ground-level ozone is principally an urban problem, it and its precursor emissions can travel long distances, resulting in elevated ozone levels in national park units. Power plants, automobiles, and factories are the main anthropogenic emitters of nitrogen oxides. Vehicles and industries also emit VOCs. Natural biogenic VOC emissions are also significant in some geographic areas.

Ozone affects human health, causing acute respiratory problems, aggravation of asthma, temporary decreases in lung capacity in some adults, inflammation of lung tissue, and impairment of the body's immune system. Chamber studies have shown ozone effects to birds and other wildlife. However, these effects to birds and wildlife have not been demonstrated in the wild. Effects to vegetation have been widely documented and ozone is one of the most widespread pollutants affecting vegetation in the U.S. Ozone enters plants through leaf stomata and oxidizes plant tissue, causing changes in biochemical and physiological processes. Both visible foliar injury (e.g., stipple and chlorosis) and growth effects (e.g., premature leaf loss, reduced photosynthesis, and reduced leaf, root, and total dry weights) can occur in sensitive plant species. Long-term exposures can result in shifts in species composition, with ozone tolerant species replacing intolerant species.

Research shows that some plants are more sensitive to ozone than humans, and effects to plants occur well below the EPA standard. Ozone causes considerable damage to vegetation throughout the world, including agricultural crops and native plants in natural ecosystems. Ozone effects on natural vegetation have been documented throughout the U.S., particularly in many areas of the East and in California. A relatively small number of national parks have been surveyed for ozone injury; injury has been documented in Great Smoky Mountains, Shenandoah, Lassen Volcanic, Sequoia/Kings Canyon, and Yosemite National Parks.

Scientists use various metrics to describe ozone exposure to plants, in addition to the 1-hour or 8-hour average concentrations reported by EPA. These metrics, the Sum06 and the W126, are believed to be biologically relevant, as they take into account both peak ozone concentrations and cumulative exposure to ozone. Hourly concentrations from a continuous or portable continuous ozone analyzer are needed to calculate either metric.

Sum06 -- The running 90-day maximum sum of the 0800-2000 hourly ozone concentrations of ozone equal to or greater than 0.06 ppm. The Sum06 is expressed in cumulative ppm-hr. Several thresholds have been developed for Sum06:

Natural Ecosystems	8 - 12 ppm-hr	(foliar injury)
Tree Seedlings	10 - 16 ppm-hr	(1-2% reduction in growth)
Crops	15 - 20 ppm-hr	(10% reduction in 25-35% of crops)

W126 -- A cumulative index of exposure that uses a sigmoidal weighting function to give added significance to higher concentrations of ozone while retaining and giving less weight to mid and lower concentrations. The number of hours over 100 ppb (N100) is also considered in assessing the possible impact of the exposure. The W126 index is in cumulative ppm-hr. Several thresholds have been developed for W126:

	W126	N100
Highly Sensitive Species	5.9 ppm-hr	6
Moderately Sensitive Species	23.8 ppm-hr	51
Low Sensitivity	66.6 ppm-hr	135

In a natural ecosystem, many other factors can ameliorate or magnify the extent of ozone injury at various times and places such as soil moisture, presence of other air pollutants, insects or diseases, and other environmental stresses.

Ozone sensitive and bioindicator plant species have been identified for all of the SOPN units except Sand Creek Massacre NHS (at the time of this report, NPSpecies did not have a plant list for the unit). Species were identified by cross-referencing NPSpecies with sensitive species identified in "Ozone Sensitive Plant Species on National Park Service and U.S. Fish and Wildlife Service Lands" (2003) at http://www2.nature.nps.gov/air/Pubs/BaltFinalReport1.pdf.

Sensitive species are those that typically exhibit foliar injury at or near ambient ozone concentrations in fumigation chambers and/or are species for which ozone foliar injury symptoms in the field have been documented by more than one observer. Bioindicator species for ozone injury meet all or most of the following criteria: 1) species exhibit foliar symptoms in the field at ambient ozone concentrations that can be easily recognized as ozone injury by subject matter experts, 2) species ozone sensitivity has been confirmed at realistic ozone concentrations in exposure chambers, 3) species are widely distributed regionally, and 4) species are easily identified in the field. Because of these attributes, bioindicator species are recommended for field surveys to assess ozone injury.

NPS completed a risk assessment for parks in 2004, based on the concept that foliar ozone injury on plants is the result of the interaction of the plant, ambient ozone, and the environment. That is, the risk for foliar injury is high if three factors are present: species of plants that are genetically predisposed to ozone, concentrations of ambient ozone that exceed a threshold required for injury, and environmental conditions, primarily soil moisture, that foster gas exchange and the uptake of ozone by the plant.

The assessment used ozone data from 1995-1999 to evaluate risk. Chickasaw NRA was determined to be at high risk from ozone injury; Lyndon B. Johnson was at moderate risk; the remaining units are thought to be at low risk (the assessment was not done for Sand Creek Massacre NHS or Washita Battlefield NHS, as these units were not part of the network when the assessment was initiated).

Visibility Monitoring

Estimates of visibility conditions for the SOPN units can be obtained from AirAtlas. Visibility-impairing particles and gases are monitored nationwide through the IMPROVE program. Most IMPROVE monitors are located in or near Class I air quality areas in order to characterize visibility conditions and assess progress towards visibility improvement under the Regional Haze Program (http://www.epa.gov/air/visibility/program.html). Tribes and other agencies have also placed IMPROVE monitors at certain locations (table 1, figure 2). Each IMPROVE site has a fine particle sampler that measures the types and amounts of particles that obscure visibility. Data are available from the Visibility Information Exchange Web System (VIEWS) at http://vista.cira.colostate.edu/views/.

Visibility is not monitored in any of the SOPN park units. However, visibility impairment is regional in nature and nearby IMPROVE samplers indicate that visibility is degraded to some extent throughout the SOPN area. Trend analysis indicates that visibility is improving slightly on the clearest days and worsening on the haziest days in many areas of the West (Appendix A, figures A.5-A.6). States are required to develop plans to make progress towards the national goal of "the prevention of any future, and the remedying of any existing, impairment of visibility in mandatory Class I federal areas which impairment results from manmade air pollution." Regional planning organizations are currently discussing these plans. The regional planning group for the western U.S., including Colorado and New Mexico, is the Western Regional Air Partnership (WRAP), with information at www.wrapair.org. The regional planning group for the central U.S., including Kansas, Oklahoma, and Texas, is the Central States Regional Air Partnership (CENRAP), with information at http://cenrap.org/.

Toxic Air Pollutant Monitoring (Mercury Deposition Monitoring)

Monitoring of toxic air pollutants, including organic chemicals (e.g., pesticides, herbicides, PCBs, dioxin) and heavy metals, has been done in some areas of the country on an ad hoc basis, but has not been done as part of a long-term nationwide network. An exception is the Mercury Deposition Network, which collects rainfall for mercury analysis at over 60 sites nationwide (http://nadp.sws.uiuc.edu/mdn/). MDN monitors near SOPN units are listed in table 1. Sources of mercury include atmospheric deposition, mining activities, and natural sources. Coal contains mercury and large coal-burning power plants are major sources of mercury to the atmosphere and, eventually, terrestrial and aquatic ecosystems. Bioaccumulation of mercury in fish and wildlife has resulted in fish consumption advisories, and neurological and reproductive effects to wildlife and humans.

Initial Recommendations

- Obtain air quality data summaries and annual reports from NPS Air Resources Division (http://www2.nature.nps.gov/air/index.htm).

- Consider a scouting survey to examine vegetation for ozone injury at Chickasaw NRA.

- Periodically update ozone risk assessments for SOPN park units, which were based on 1995-1999 ozone data. Increasing ozone concentrations in the region may result in higher risk categories for some parks.

Relevant Websites

ARIS at http://www2.nature.nps.gov/air/
NPS AirWeb at http://www2.nature.nps.gov/air/
Air Atlas at http://www2.nature.nps.gov/air/Maps/AirAtlas/index.htm
NADP at http://nadp.sws.uiuc.edu/
MDN at http://nadp.sws.uiuc.edu/mdn/
CASTNet at http://www.epa.gov/castnet/
EPA Ozone (AirData) at http://www.epa.gov/air/data/index.html

NPS Ozone Data at http://www2.nature.nps.gov/air/data/index.htm
IMPROVE at http://vista.cira.colostate.edu/views/
Pollution sources and air quality data at http://www.epa.gov/air/data/index.html
VIEWS at http://vista.cira.colostate.edu/views/

Appendix A: Trends in Ozone, Visibility, and Wet Deposition

1994-2003

(Source: FY 2004 Annual Performance Report: Government Performance and Results Act, Air Resources Division)

Figure A.1

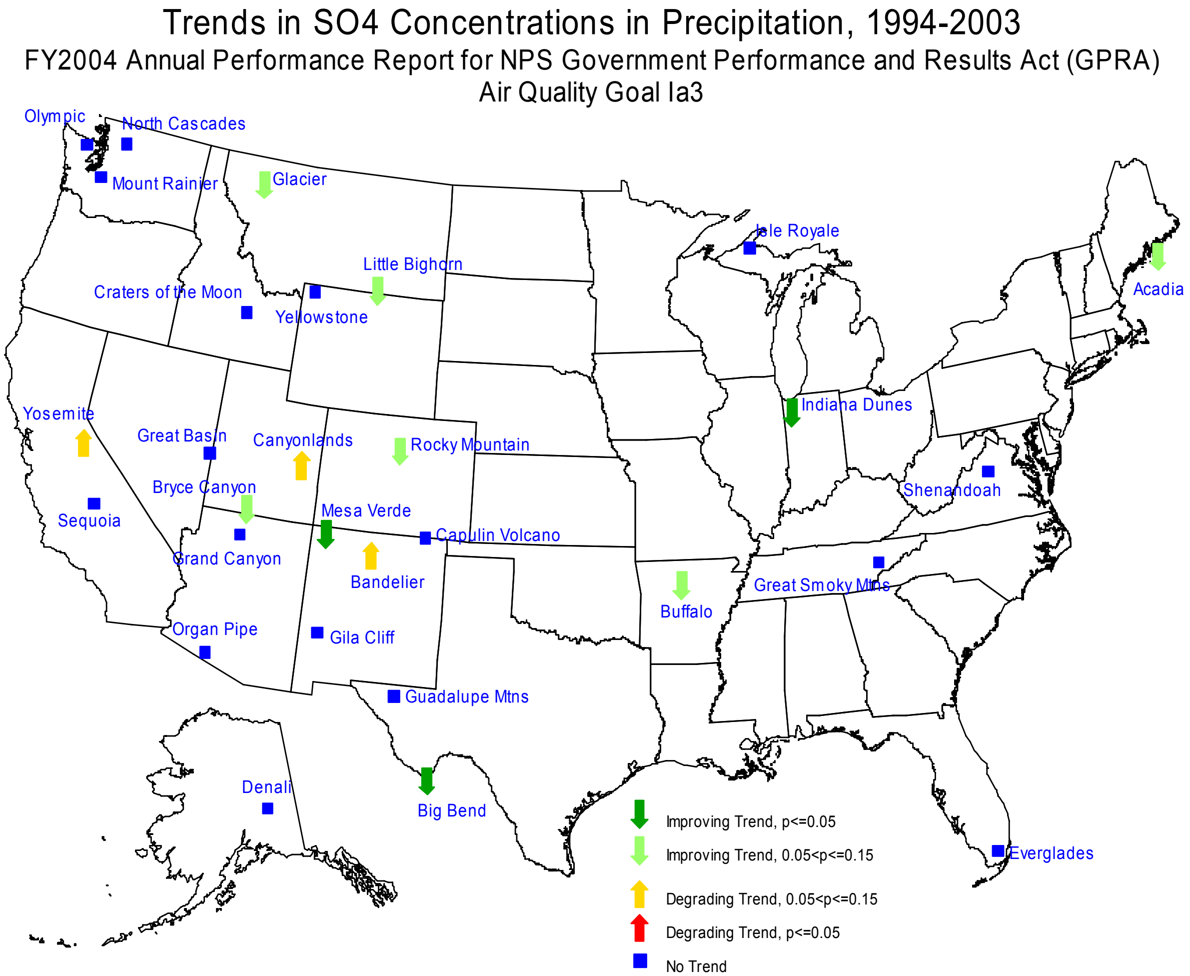

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Figure A.2

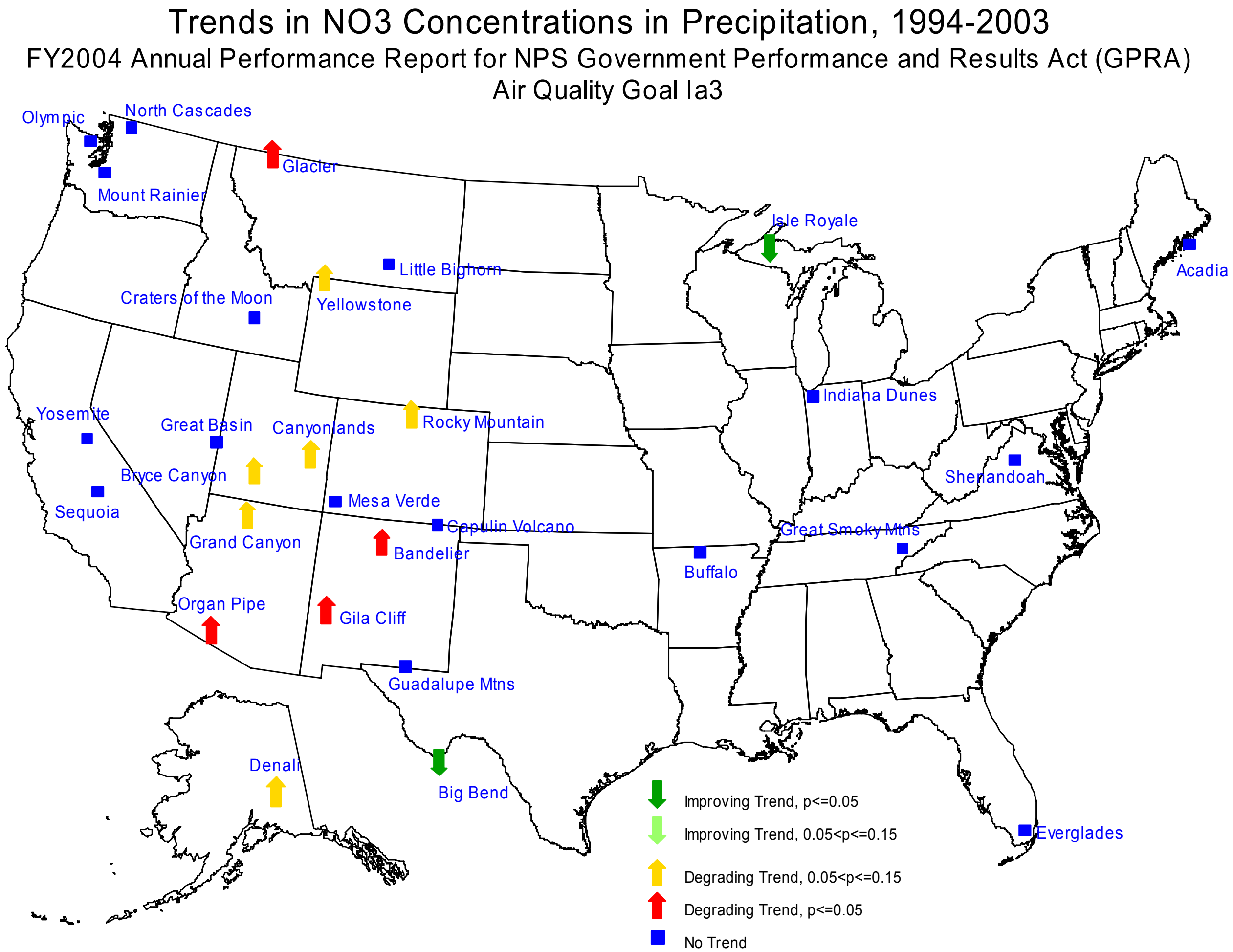

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Figure A.3

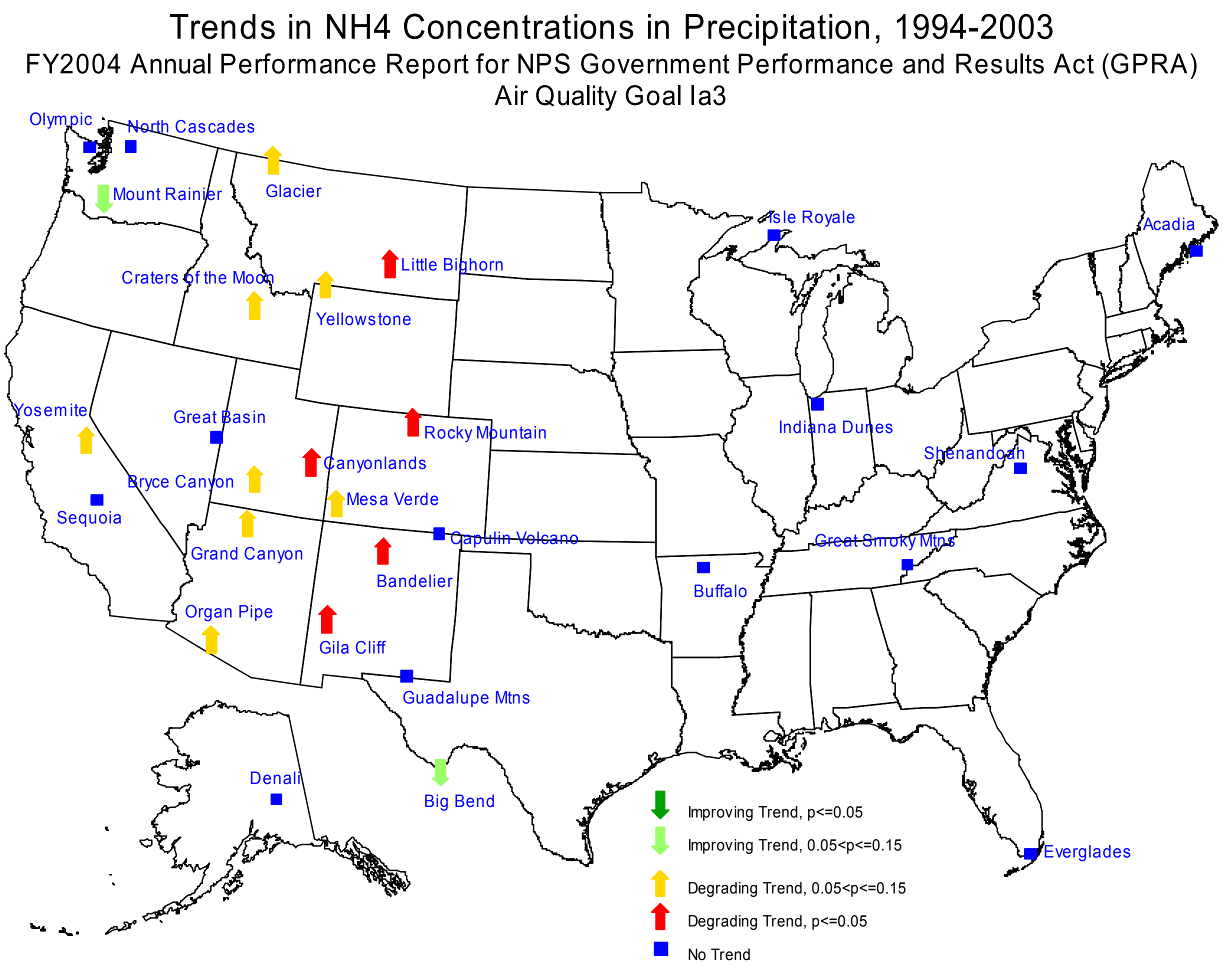

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Figure A.4

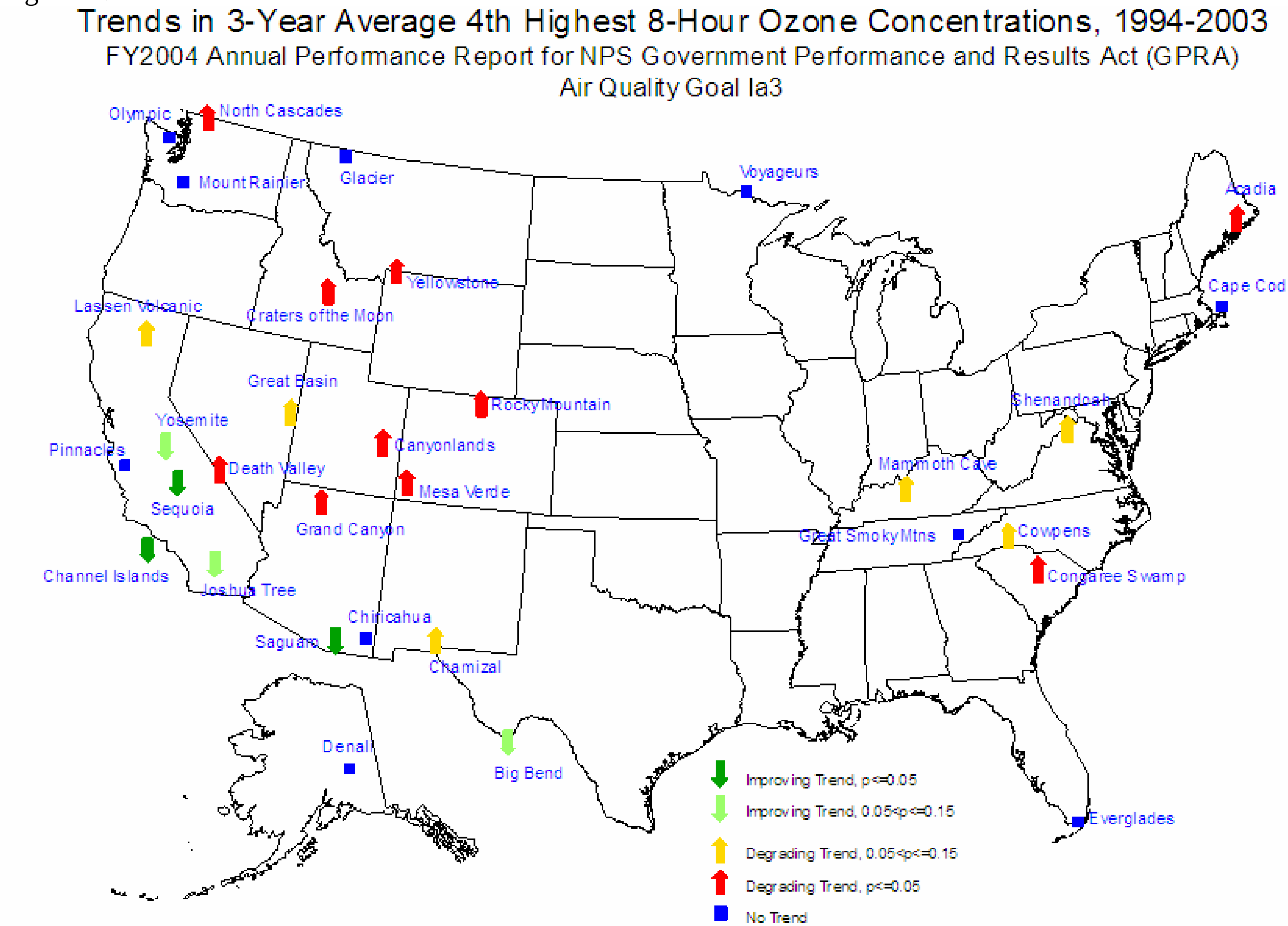
Trends in 3-Year Average 4th Highest 8-Hour Ozone Concentrations, 1994-2003
FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3
Olympic
North Cascades
Mount Rainier
Glacier
Voyageurs
Acadia
Yellowstone
Craters of the Moon
Lassen Volcanic
Cape Cod
Great Basin
Rocky Mountain
Shenandoah
Yosemite
Canyonlands
Pinnacles
Death Valley
Mammoth Cave
Mesa Verde
Sequoia
Grand Canyon
Great Smoky Mtns
Cowpens
Channel Islands
Joshua Tree
Congaree Swamp
Chiricahua
Saguaro
Chamizal
Denali
Big Bend
Everglades
Improving Trend, p<=0.05
Improving Trend, 0.05<p<=0.15
Degrading Trend, 0.05<p<=0.15
Degrading Trend, p<=0.05
No Trend

Figure A.5

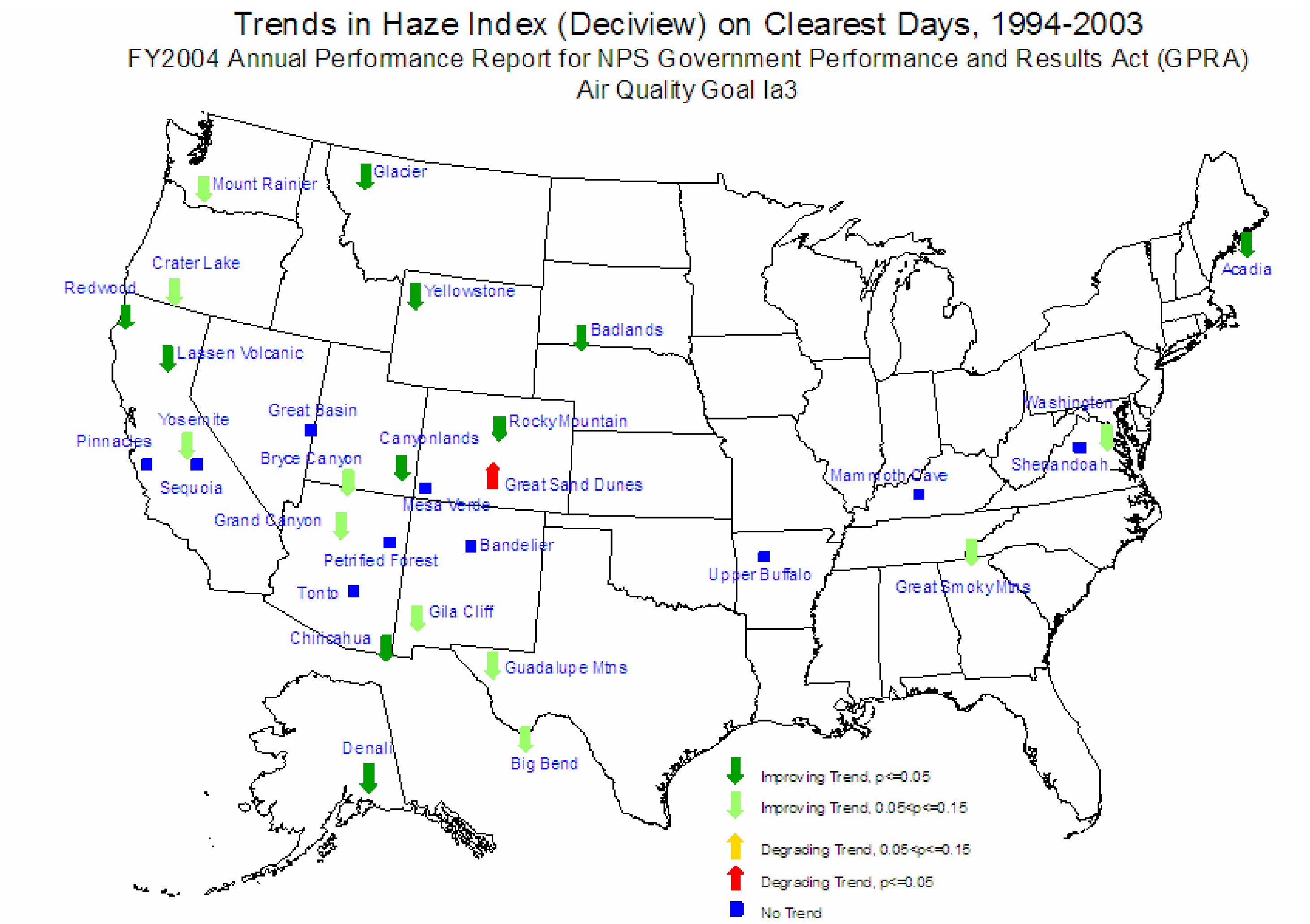
Trends in Haze Index (Deciview) on Clearest Days, 1994-2003
FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)
Air Quality Goal Ia3
Mount Rainier
Glacier
Crater Lake
Redwood
Yellowstone
Badlands
Acadia
Lassen Volcanic
Great Basin
Yosemite
Pinnacles
Canyonlands
Rocky Mountain
Bryce Canyon
Sequoia
Great Sand Dunes
Mesa Verde
Washington
Shenandoah
Mammoth Cave
Grand Canyon
Bandelier
Petrified Forest
Upper Buffalo
Tonto
Great Smoky Mtns
Gila Cliff
Chiricahua
Guadalupe Mtns
Denali
Big Bend
Improving Trend, p<=0.05
Improving Trend, 0.05<p<=0.15
Degrading Trend, 0.05<p<=0.15
Degrading Trend, p<=0.05
No Trend

Figure A.6

Trends in Haze Index (Deciview) on Haziest Days, 1994-2003

FY2004 Annual Performance Report for NPS Government Performance and Results Act (GPRA)

Air Quality Goal Ia3